SYNOPSIS

Measurement of Radon, Thoron and their Progeny Concentrations in Hamirpur District of Himachal Pradesh

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Introduction

Radioactivity is the spontaneous emission of energy in the form of particles or waves or both from the atomic nucleus of certain elements. It was discovered in 1896 by Henri (French physicist) who observed that uranium emitted penetrating rays are continuous and without initiation. This research work was followed by Pierre and Marie Curie shortly afterward. The research work above led to the discovery that radioactive atoms emit three different kinds of radiation namely alpha particle, beta particle and gamma rays. Alpha particles consists of two protons and two neutrons. They can ionize the other particles very strongly. Due to their size and charge, alpha particles are simply able to penetrate skin and can be stopped completely by a sheet of paper. Beta radiation consists of fast moving electrons ejected from the nucleus of an atom. Beta particles can also ionize the atoms, but not as strongly as alpha particles do. Beta radiation has a negative charge and is about $1/7000^{th}$ the size of an alpha particle and so is more penetrating. However, it can still be stopped by a small amount of shielding, such as a sheet of plastic. Gamma radiation is highly penetrating type of radiation. It is usually emitted immediately after the ejection of an alpha or beta particle from the nucleus of an atom Gamma rays do not ionise the atom, they may cause atoms to emit other particles which causes ionization. Because it has no mass or charge, it can pass through the human body, but will be absorbed by denser materials such as concrete or lead.

Radon is a natural radioactive gas that occurs everywhere in the world. Radon is a chemical element with symbol Rn and atomic number 86. It is a radioactive, colourless, odourless, tasteless noble gas occurring naturally and not detectable by human senses alone. One of the fact is that radon, thoron and their progeny concentrations contribute the most to the natural dose to general population. Radon and thoron present in outdoor and indoor air as they exhaled from soil and building materials. It is observed that inhalation of radon and their progeny concentrations has been shown experimentally, to cause lung cancer in men exposed for long time to such air. The measurement of radon, thoron and their progeny concentrations also leads to the knowledge of the presence of radioactive elements. Since uranium 238 is the parent nuclei of radon and thorium 232 that of thoron, hence with the concentrations of these gases in air, one can predict the

presence of high or low concentrations of the source radioactive elements. In India measurement of radon and thoron concentrations have been done for the past many years which were undertaken by Environment Assessment Division, Bhabha Atomic Research Centre and some of the universities. Many techniques are in use to measure the radon, thoron levels in air and soil. Many dosimeters employing tracks detection have been developed. The nuclear track detector technique is the most reliable method. Fault region also plays important role in the out gassing process of radon and thoron from soil. Radon is the heaviest member of the rare gas group and has a half life of 3.82 days. Thoron is an isotope of radon. It has atomic number 86, mass number 220 and half life of 55.3 seconds. Radon and thoron decay with the emission of alpha particles and produce daughter nuclei- polonium, lead and bismuth. These daughter nuclei emit alpha or beta particles. Radon can move more rapidily through permeable soils such as coarse sand and gravel than through impermeable soil such as clays. Radon can move through cracks in rocks and through pore spaces in soils. Basic sources of radon are rocks, soil, ground water and building materials. Radon's primary pathway is from the earth through the basements of houses and other buildings and into air that people breathe. The present work will help in understanding the status of indoor and outdoor radon, thoron and their progeny concentrations and status of the exhalation of these gases from air and soil. Present work tries to explore the concentrations of radon, thoron and their progeny in Hamirpur district of Himachal Pradesh. In this experimental work, indoor concentrations are measured by using Solid State Nuclear Track Detector (SSNTD).

Literature Review

In the 19th century about 75% of the miners died from lung cancer. Identification of radon by Marie and Pierre curie, the first measurements in the mines was made in 1901. After this in 1920, a correlation between radon exposure and lung cancer was suggested. This hypothesis was confirmed in 1940. Intensive mining of uranium began in the 1940s in Africa, Canada and USA. Little attention was paid to radiation protection of the workers. The first measurements in these mines was made in 1950. During the 1950 a few studies on natural radiation was carried out. Bale in 1951, introduced the idea that it was not only radon but the decay products which might be the causative agent. During

the 1960 radon indoors was studied in some countries but the extent of the research was limited, Drinking water was studied with respect to the natural radionuclides including radon in several countries e.g. Finland and Sweden. High values was found in some ground water wells. At the beginning of the 1970s there was an increasing interest in the ionising radiation indoors. In 1971 High radon levels was also found in non-uranium mines. In USA requirements was established for both the gamma and the radon progeny exposures in houses built on or from waste materials from the uranium industry. In 1980s the recommendations of the Swedish Radon Commission was used by the responsible national boards to set requirements on radon levels lower than 400 Bqm^{-3} of equilibrium equivalent concentration for existing dwellings and 70 Bqm^{-3} equilibrium equivalent concentration for newly built dwellings. It was also recommended that the level in existing dwellings should be decreased in the range 70-400 Bqm^{-3} equilibrium equivalent concentration. The limits was decreased in 1990 when better measurement techniques introduced, the health risks have been more thoroughly studied. Radon exhalation from the ground varies from place to place and by time. Over the oceans the radon concentration is very low. Therefore, the radon concentration in coastal regions vary more than over continents depending on the wind direction. Temperature inversions can give very high concentrations in regions with high radon concentrations in the earth's crust levels. United Nations Scientific Committee on the Effect of Atomic Radiation has estimated the world-wide average outdoor concentration to be 10 Bqm^{-3}. The indoor concentrations also depends on the building technique, the climate and the occupancy habits. Monitoring of radon gas in Jordan was started in 1990s.

Sharma et al., [1] has studied the Uranium, Radium and Radon exhalation rate in soil samples from some areas of Kangra District Himachal Pradesh India using solid state nuclear track detectors. They concluded that the radon exhalation rate in these samples found to vary from 15.16 to 35.11 $mBqKg^{-1}h^{-1}$. Ramola et al., [2] has studied the Measurement of Radon exhalation rate from soil samples from Garhwal region of Himalaya, India. They found that soil-gas Radon concentration was higher than the normal value. They attributed the high value of radon concentrations due to the presence of Uranium deposited in the area. Sun et al., [3] has studied the Feasibility for mapping Radon exhalation rate from soil in china. Singh et al., [4] has studied Seasonal variation

of indoor radon in dwellings of Malwa region, Punjab. They concluded that indoor radon shows high values in winter and low values in summer. Singh et al., [5] has also analyzed Ra^{226}, Th^{232} and K^{40} in soil samples collected from some area of Punjab and Himachal Pradesh, India by using gamma ray spectrometry. They found comparatively high value of Uranium in the soil of Palampur in Himachal Pradesh. They reported high values of Ra^{226} and Th^{232} in soil samples due to the presence of Uranium mineralization in Himachal Himalayas. Mehra et al., [6] has studied the Uranium, Radium, Radon exhalation rate and Indoor Radon in the environs of some areas of the Malwa Region, Punjab. They reported average Radon concentration levels and the standard deviation of the yearly values recorded in dwelling of 34 villages. Mehra et al., [7] has estimated Uranium in water samples from Malwa region of Punjab, using track etching technique. They concluded that the values of uranium concentration in water samples of these areas are lower than those reported for water samples of himachal Pradesh, India. Singh et al., [8] has studied the Uranium, Radium and Radon Measurements in the Environs of Nurpur Area, Himachal Himalayas, India. They reported positive correlation between uranium and radon exhalation rate in soil and rocks. Singh et al., [9] has studied ^{226}Ra, ^{232}Th and ^{40}K analysis in soil samples from some areas of Malwa region, Punjab, India using gamma ray spectrometry. They concluded that the total absorbed dose in the study area ranges from 58.08 $nGyh^{-1}$ to 130.85 $nGyh^{-1}$ with an average value of 79.11 $nGyh^{-1}$ and soil from these regions is safe and can be used as a construction material.

Sahoo et al., [10] estimated the Radon emanation factor in Indian building materials. They observed that fly ash samples, collected from Gujarat region, are having concentrations of natural radio nuclides higher than that was found in other building materials. Consequently, gamma dose was also high in these materials. Kumar et al., [11] has studied Radon and its progeny levels dwellings of Thankassery, Kerala. They concluded that radon concentrations vary from 44.3 to 373.3 Bqm^{-3}, whereas the annual effective dose equivalents vary from 1.7 to 14.2 mSv. Kumar et al., [12] has studied the Radioactivity measurements in the environment of the Udhampur area, Jammu and Kashmir Himalaysis, India. Positive correlation has been observed between uranium and radium. Mahur et al.,[13] has investigated Radon exhalation rate and natural radioactivity in soil samples collected from East Singhbhum shear zone in Jaduguha U-Mines area of

Jharkhand, India and its radiological implications. Zaher et al., [14] has studied the Seasonal variation of indoor radon concentration in dwellings of Alexandria City Egypt. They observed maximum radon concentrations in the winter season, whereas minimum levels observed in the summer season. Kumar et al., [15] has investigated the Uranium, Radium and Radon exhalation in some soil samples from Una district, Himachal Pradesh, India using track etching technique. They observed that Uranium concentration in soil varies from village to village. Kumar et al., [16] has studied Radon in soil gas and Natural Radionuclide in soil, rock and ground water samples. They observed concentrations of radon in soil was higher near Chamundi hills and Karighatta village in rainy season. Zubair et al., [17] has investigated the Assessment of Indoor Radon, Thoron and their decay products in the surrounding areas of Firozabad, Uttar Pradesh, India. They concluded that all values obtained were within the limit, depending on the type of house concentration, ventilation conditions and location.

Gupta et al., [18] has studied Indoor radon levels in some dwellings surrounding the national thermal power corporations, India. It is concluded that the radon levels and annual effective dose was found to be below the recommended action levels. Sharma et al., [19] has studied the Comparative Study of Indoor Radon, Thoron with radon exhalation rate in soil samples in some historical places at Jaipur Rajasthan India. Zubair et al., [20] reported Radium concentration and Radon exhalation rates of soil samples collected from some areas of Bulandshahr District, Uttar Pradesh, India by using plastic track detectors. They studied that radon becomes airborne with the attachment of dust particle and pollution, after inhalation it becomes deeply trapped in the lung. Therefore the exposure of population to high concentration of radon and its daughters for a long period leads to pathological effects like the respiratory function changes. They also studied that the average values of radium content in the studied area was comparable to the global average value of radium in soil. Yanlin et al., [21] measured Radon exhalation rate from the medium surface by tracing the radon concentration. Effective radium content and radon exhalation rates in soil samples have been measured by ‘‘Sealed Can Technique’’ using LR-115 type II plastic track detectors in Farrukhabad city of Utter Pradesh, India. They concluded that all the values of radium content in soil samples of studied area was found to be quite lower than the permissible value of 370 $Bqkg^{-1}$

recommended by Organization for Economic Cooperation and Development. Some researchers [22, 23] has measured the Radium content and Radon exhalation rates in soil samples of Al-Hindiyah city. They concluded that all the values of radium content in soil samples of study area were found to be quite lower than the permissible value of 370BqKg^{-1} recommended by organization for economic cooperation and development. Khan et al., [24] has Monitored radon, thoron levels and their Seasonal Variation in some selected dwellings in and around Rampur city using Solid State Nuclear Track Detector (SSNTD). Narang et al., [25] has studied assessment of Indoor Radon in some areas of Northern Punjab using plastic track detector. Mehta et al., [26] has measured Indoor Radon, Thoron and their Progeny levels in dwellings of Ambala District Haryana, Northern India using solid state nuclear track detectors. They concluded that the annual effective dose received by the inhabitant of these dwellings varied from 0.15 mSv to 2.30 mSv and depends upon the ventilation condition of the dwellings. Verma et al., [27] has studied assessment of indoor radon, thoron and their progeny in dwellings in India using track etch detectors. They concluded that the variation in the above parameters was strongly influenced by the type of dwelling construction and their ventilation conditions. Kumar et al., [28] has studied the Effect of moisture and additive on radon exhalation rate from concrete. They concluded that the various additives like silica fume and fly ash may cause the decrease of radon exhalation up to optimum value after that it increases. The radon exhalation rate also varied with age of concrete. Kaur et al., [29] has investigated the Radon concentration in water and radon exhalation rate in soil samples belonging to Kapurthala district, Punjab, India. They concluded that these areas are safe from the health hazard point of view as for as the radon is concerned. A good correlation has been observed between radon and exhalation rate. Hosoda et al., [30] has investigated the Effect of soil moisture content on Radon and Thoron exhalation. They concluded that the measured exhalation rates decrease steadily. Both Radon and Thoron exhalation rates decrease to approximately 1/5 with increase in the soil moisture content from 8-24%. Almayahi et al., [31] has studied natural radioactivity of soil samples in Najaf City using NaI Spectrometry.

Research Gap Identification

Although a number of research groups from India and abroad explored radon in Himalayan region especially in Himachal Pradesh but, still the region along Jwalamukhi fault line remained unexplored. This Fault is extends from Jawalamukhi (Kangra) to Badsar (Hamirpur), this area falls under seismic zone V, hence this research is focused on this area.

Proposed Methodology

A number of methods are available for the measurement of radon, thoron concentrations and radioactivity analysis. The type of detectors for the measurement of radioactivity are also many. The detectors and the instrumentation associated with detectors perform with different efficiencies to radiation detection depending on many factors. Area of Hamirpur District in Himachal Pradesh is under observation. Ten to Twenty soil samples will be collected randomly from different places near to Hamirpur district by grab sampling method. The collected soil will be packed and sealed in airtight dry polyethylene bags. The collected samples will be converted in powdered form and sealed Can technique will be applied for the measurement of radon exhalation rate.

In the present experimental work, for indoor and outdoor measurement a special detector film, LR-115 has been used. This detector consists of thin films of Cellulose nitrate [$(C_6 H_{10}O_5)$ n] Coloured Deep red and coated on a 100 µm thick polyester backing. In case of indoor, detectors have been hanged overhead on the ceiling at the height of minimum 1.5m from the floor and at least 10 cm away from any surface for minimum 90 days. For seasonal variations in concentrations of these gases will be measured particularly during rainy, winter and summer seasons in a year. These detectors will be exposed in each season for about four months. The room size, distance of the detector from roof wall and floor and ventilations present at that specific room will be recorded. The number of windows, ventilations and doors are also counted. After 90 days the exposed films will be etched in an etching bath using 2.5N NaOH solution at $60^{\circ}C$ for 90 minutes during which 4µm thickness is etched away. Etching of the film is necessary because the tracks produced on the films are visible for counting only after etching. After etching the detectors thoroughly washed and scanned manually for track

density measurements using optical microscope at a magnification of 400X. But in case of outdoor, the solid state nuclear track detector placed 50 cm below the earth surface for the period of 15 days. After every 15 days the detectors will be replaced by new ones and exposed films are then etched in an etching bath using 2.5N NaOH solution at 60°C for 90 minutes during which 4μm thickness is etched away. After etching the detectors thoroughly washed and scanned manually for track density measurements using optical microscope at a magnification of 400X.

Objectives

i. To find the seasonal concentrations of indoor radon, thoron and their progeny.
ii. To find the seasonal concentrations of outdoor radon, thoron and their progeny.
iii. To find the radon, thoron and their daughter concentrations in soil samples collected from different places by using gamma ray spectroscopy.
iv. To analyse the water samples from different areas of Hamirpur.
v. To study the correlation between ^{226}Ra, ^{232}Th and ^{222}Rn, ^{220}Rn.

Formula used: The formula used for calculating radon concentration is given [2] as:

$$C_R = \frac{T_P}{\text{Calibration factor} \times \text{exposure period(days)}}$$

Where C_R is the radon concentration in Bq / m^3 and T_P is the track density of films (tracks / cm^2) in pinholes compartment. Calibration factor is the quantity which is used for converting the observed track density rates to the activity concentration.

The formula used for calculating thoron concentration is given as:

$$C_T(Bqm^{-3}) = \frac{T_F - T_P}{\text{Calibration factor} \times \text{exposure period(days)}}$$

Where C_T is the thoron concentration, T_F is the track density of films in filter compartment and T_P is for pinhole compartment. The content of source radioactive elements especially radon and thoron in the different places of Hamirpur districts can be determined by using gamma ray spectroscopy.

Thesis Outline

The arrangement of the thesis in the form of chapters will be as follow:

CHAPTER 1: This chapter will contain the complete introduction and review of literature related to the present studies.

CHAPTER 2: This chapter will contain the theoretical formula and complete methodology for indoor and outdoor study.

CHAPTER 3: This chapter will contain details of calculation and result obtained from the experiments carried out in the present study.

CHAPTER 4: This chapter will include the possible and even critical discussion on the results obtained in the present investigations.

CHAPTER 5: This chapter will present the conclusion that could be drawn out of the present research work.

Publications:

1) J. Kumar, N. Thakur, P. Katnauria, R. Bhadwal and G. Kumar, Health Risk Assessment Based on Radioactivity Measurement in soil samples collected from some areas of Mandi district in Himachal Pradesh. CPUH-Research Journal**.** 1(2015)14.

2) N. Thakur, J. Kumar, R. Bhadwal, K. C. Thakur and Y. Sharma, Radioactivity Measurement along Jwalamukhi Thrust in Himachal Pradesh, India. CPUH-Research Journal. 1 (2015) 23.

Research Plan Schedule

Research Activity	Progress in Month											
	3	6	9	12	15	18	21	24	27	30	33	36
Course work, extensive literature survey or design of work	Jan 2015 to Jan 2016											
Research gap identification and development of methodology			Sep 2015 to March 2016									
Experimental Work or Field Work					Jan 2016 to Jan 2017							
Lab Work and Calculations						July 2016 to June 2017						
Conclusion, manuscript preparation for publication and thesis writing										Jul 2017 to Dec2017		

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